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A Western Larch-Engelmann Spruce Spacing Study in Eastern Oregon: Results After 10 Years

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Abstract

The 10-year growth response from a spacing study in an even-aged stand of western larch (*Larix occidentalis* Nutt.) and Engelmann spruce (*Picea engelmannii* Parry ex Engelm.), thinned at age 10 to 9- and 15-foot spacings, was measured in eastern Oregon. Both basal area and total cubic volume increment per acre increased at the narrower spacing while diameter growth per tree was less than at the wider spacing. Height growth was not affected by spacings. Larch grew about twice as fast as spruce in height and diameter resulting in the development of a stratified two-storied stand.

Keywords: Growth response, thinnings (-stand volume,), spacing thinnings, thinning effects, western larch, *Larix occidentalis,* Engelmann spruce, *Picea engelmannii*, eastern Oregon.

Introduction

Spacing and thinning studies located in stands of various ages and species or on different sites provide information on long-term growth and yield of managed stands that is useful in developing and verifying simulation models and designing thinning schedules to meet land management objectives. Considerable information is available on the growth response of pure, even-aged stands to thinning but little is known about the response of mixed species stands, especially those containing species that differ greatly in tolerance to shade.

In 1971, a small spacing study was begun in a young, even-aged stand of western larch (*Larix occidentalis* Nutt.) and Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) in northeastern Oregon. The purpose of this study was to compare diameter, height, basal area, and volume growth for these species at two spacings. This paper reports results from the first 10 years of the study consisting of two 5-year growth periods (1972-76 and 1977-81).

Study Area and Methods

The study is located in the La Grande District of the Wallowa-Whitman National Forest in the Anthony Lakes burn which occurred in 1960. The study is on a northwest-facing, 15-percent slope at an elevation of about 6,000 feet. The soil is a moderately deep and well-drained Typic Vitrandept (Olot series) that developed in volcanic ash and colluvium and residuum weathered from basalt. It consists of about 15 inches of silty loam ash overlaying 20 to 25 inches of silty loam residual soil.[1]

[1] Personal communication from Dan Harkenrider, Union Ranger District, Wallowa-Whitman National Forest, Union, Oregon.

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Table 1—Characteristics of western larch-Engelmann spruce plots in 1971, 1976, 1981

Spacing	Species composition		Number of trees	Trees 0.6-inch d.b.h. or greater		Quadratic mean diameter[1]			Average height[2]			Basal area[1]			Total volume[1]		
	Larch	Spruce				Larch	Spruce	Combined	Larch	Spruce	Combined	Larch	Spruce	Combined	Larch	Spruce	Combined
				Number													
Feet	--Percent--		Per acre	per acre	Percent	--------Inches-------			--------Feet----------			-Square feet per acre-			--Cubic feet per acre--		
1971:																	
9 x 9	50	50	538	46	9	1.0	--	1.0	5.1	2.5	3.7	0.2	--	0.2	2.0	--	2.0
15 x 15	53	47	193	16	8	1.3	--	1.3	5.1	2.6	3.9	.1	--	.1	1.1	--	1.1
1976:																	
9 x 9	49	51	531	300	56	1.7	1.0	1.6	11.4	5.1	8.1	3.6	0.3	3.9	31.0	2.7	33.7
15 x 15	53	47	193	124	64	1.7	0.9	1.6	10.8	5.4	8.3	1.6	.1	1.7	13.7	1.3	15.0
1981:																	
9 x 9	49	51	531	508	96	2.9	1.3	2.3	16.7	7.9	12.2	11.7	2.2	13.9	102.3	16.9	119.2
15 x 15	53	47	193	185	96	3.0	1.7	2.5	16.2	8.8	12.9	5.1	1.2	6.3	44.3	8.5	52.8

1/ All trees 0.6-inch d.b.h. and larger.

2/ All trees.

The study area is located in an *Abies lasiocarpa/Vaccinium scoparium* plant community (Hall 1973). Typical ground cover in this community consists primarily of grouse huckleberry (*Vaccinium scoparium* Leib.) and small amounts of species such as boxwood (*Pachistima myrsinites* (Pursh) Raf.), side-flowered mitrewort (*Mitella stauropetala* Piper), and sidebells pyrola (*Pyrola secunda* L.). Site index, based on Schmidt and others (1976) curves, of older larch in the area indicates a height of 45 feet at age 50.

The study was installed in a naturally regenerated young stand of larch, spruce, and lodgepole pine (*Pinus contorta* Dougl. ex Loud.) that was about 10 years old when the study began in 1971. It is an initial spacing experiment testing two spacings (9 by 9 and 15 by 15 feet) created by thinning. Each spacing was replicated two times for a total of four plots. All lodgepole pine were removed from the plots. Thirty-five trees were measured in each plot. The goal was an alternate arrangement of larch and spruce. Plot size including buffer strips thus depended upon spacing. Plots at the 9-foot spacing are 0.19 acre in size and those at the 15-foot spacing are 0.29 acre. No further thinning will be done in these plots.

Total height of all plot trees was measured to the nearest 0.1 foot, and diameter at breast height (d.b.h.) of trees 0.6 inch or larger was measured to the nearest 0.1 inch in 1971, 1976, and 1981. In 1976, diameter and bark thickness were measured at several points on the boles for 12 trees per plot. Data from all plots were used to construct a combined equation for both species expressing total cubic volume inside bark as a function of diameter^2 x height (D^2H). This equation was used for volume estimation at each measurement.

After thinning, average height of larch at both spacings was 5.1 feet, about twice as tall as the spruce on these plots which were 2.5 feet (table 1). Average d.b.h. of larch of measureable size was 1.0 inch at the 9-foot spacing and 1.3 inches at the 15-foot spacing. Species composition at each spacing was about equal; 50 percent larch and 50 percent spruce.

Analyses of variance were used to compare spacings, species, and growth periods for diameter, height, basal area, and volume growth. The experiment was a split-split plot: Whole-plot treatments were spacings; split-plot treatments were species; and split-split-plot treatments were time periods.

Table 2—Periodic annual increment of western larch and Engelmann spruce saplings during two 5-year measurement periods from 1972 to 1981

Spacing	Diameter growth1/			Height growth			Gross basal area growth			Gross total volume growth		
	Larch	Spruce	Combined	Larch	Spruce	Combined	Larch	Spruce	Combined	Larch	Spruce	Combined
Feet	-------Inches--------			-------Feet----------			-Square feet per acre-			-Cubic feet per acre-		
From age 10 to 15 (1972-76)												
9 x 9	0.34	--	0.34	1.3	0.5	0.9	0.68	0.06	0.74	5.8	0.5	6.3
15 x 15	.33	--	.33	1.1	.6	.9	.30	.03	.33	2.5	.3	2.8
From age 15 to 20 (1977-81)												
9 x 9	.26	0.17	.22	1.1	.6	.9	1.63	.37	2.00	14.3	2.9	17.2
15 x 15	.28	.24	.26	1.1	.7	.9	.70	.21	.91	6.1	1.5	7.6

1/ Arithmetic mean diameter growth of trees 0.6-inch d.b.h. or larger at beginning of each 5-year period and living through the period.

Results

Diameter Growth

Significant differences ($P<0.05$) in periodic annual diameter growth existed between spacings with trees at the wider spacing growing at an average rate of 0.26 inch compared to 0.22 inch at the closer spacing during the second 5-year period (table 2). Larch grew significantly faster in diameter ($P<0.01$) than spruce: Larch averaged 0.27 inch per year over both spacings compared to an average of 0.21 inch per year for spruce.

At the beginning of the first 5-year period, none of the spruce had reached 0.6-inch d.b.h. and only six larch in the 9-foot plots and six in the 15-foot plots were that size. During the second period, ingrowth resulted in more trees (both larch and spruce) reaching 0.6-inch d.b.h. Diameter growth in table 2 may not agree with differences between mean diameters at the beginning and end of growth periods shown in table 1. This is because average diameters at each measurement are based on trees 0.6-inch d.b.h. or larger at the time, but growth is based only on trees of that size in 1971 and 1976.

Height Growth

Larch grew about twice as fast in height as spruce at both spacings and during both periods, averaging about 1.2 feet per year compared to about 0.6 foot for spruce (table 2). This difference was significant ($P<0.01$). Only small differences in height growth were found between spacings or periods and thus there were no significant interactions. Height growth of individual trees varied greatly and ranged from 3.5 to 17.9 feet for larch and from 1.9 to 10.2 feet for spruce during the 10-year study period. After 20 years of growth, larch were about twice as tall as spruce because of the more rapid early height growth of larch (fig. 1).

Figure 1.—Comparison of larch and spruce saplings showing difference in total height after 20 years.

Basal Area and Volume Growth

Both basal area and total cubic volume growth per acre showed the same response to spacing, among species, and between periods. Annual volume increment, for example, more than doubled from 10.4 to 23.5 cubic feet per acre as spacing decreased from 15 to 9 feet (table 2). This difference was significant ($P<0.05$). Because of the more rapid diameter and height growth of the larch, volume increment of this species was more than five times greater than that of spruce (averaged over both spacings and periods) and the difference was highly significant ($P<0.01$). Larch accounted for about 85 percent of the total volume and basal area growth during the 10 years of the study. This difference in growth rate between larch and spruce should continue but is expected to decline as the spruce become larger. Basal area and volume increment increased significantly ($P<0.01$) during the second 5-year period as more trees reached 0.6-inch d.b.h. (ingrowth) and diameter and height were greater.

In addition to the relationships just described, significant interactions ($P<0.05$) were also found between spacings and periods and between species and periods. The species-period interaction for volume growth is shown in figure 2. Although growth of both species increased during the second period, growth of larch relative to spruce was considerably greater during the second period. This resulted in a growth differential between the species of about 8 cubic feet per acre per year during the second period compared to only 3.8 cubic feet during the first period.

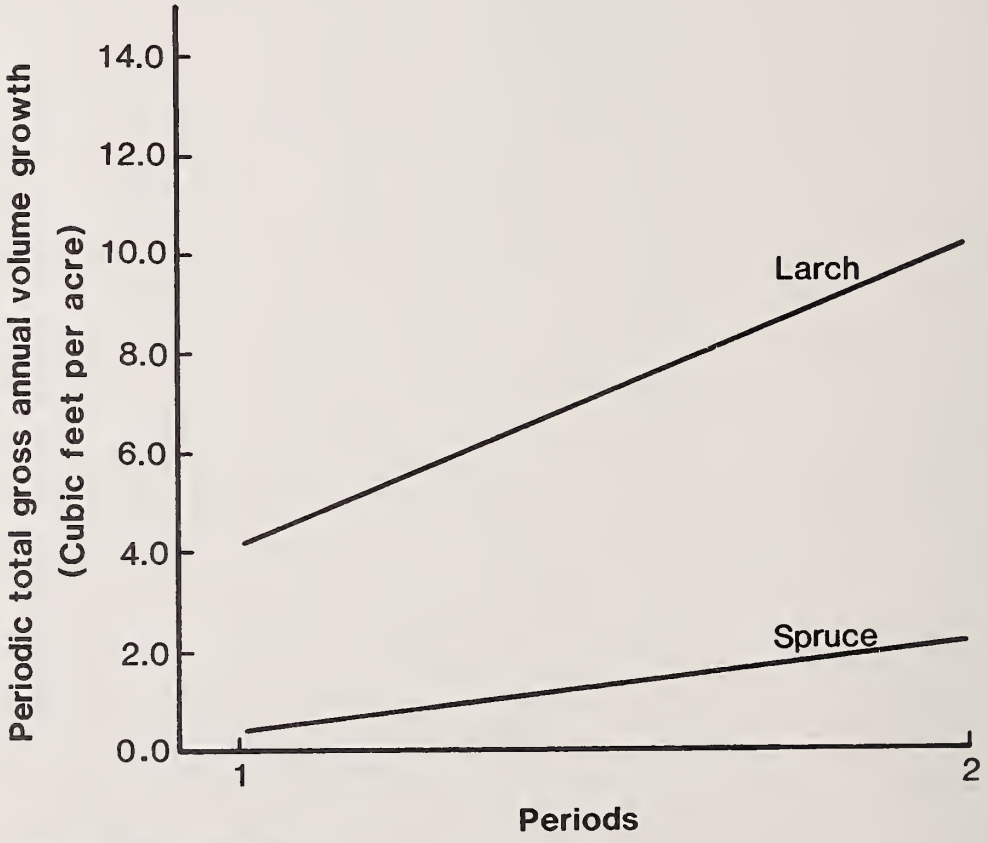

Figure 2.—Periodic total gross annual cubic volume increment of larch and spruce during first and second 5-year periods averaged over both spacings.

Mortality

Mortality was light during the 10 years of this study. Only one tree (a larch) died on a plot having a 9-foot spacing during the first 5-year period, and none died during the second period.

Discussion

The stand where these plots are located is a classic example of the development of a stratified, two-storied, even-aged stand consisting of a fast growing, intolerant overstory species and a slower growing, more tolerant understory species. Twenty years after both larch and spruce became established in the burned area, average height and diameter of the larch is about double that of the spruce (table 1). The growth rate of larch should continue to exceed that of spruce for at least 50 years resulting in a more pronounced stratification in height and diameter between the two species. As time goes by, this stand should take on the appearance of an uneven-aged stand even though this structure is due to differences in growth rate rather than time of establishment.

Although data on stand response to spacing are limited because only two spacings were tested, the typical pattern of greater diameter growth per tree and less volume growth per acre with wider spacing is evident after 10 years of stocking regulation. Perhaps the most valuable aspect of this study is the opportunity to document the development of a two-storied, even-aged stand from time of origin.

Acknowledgment

WALTER G. DAHMS, formerly with the Pacific Northwest Forest and Range Experiment Station and now retired, was responsible for the design and installation of this study.

Metric Equivalents

1 foot = 0.3048 meter
1 inch = 2.54 centimeters
1 acre = 0.4047 hectare
1 square foot per acre = 0.2296 square meter per hectare
1 cubic foot per acre = 0.0700 cubic meter per hectare
1 tree per acre = 2.47 trees per hectare

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